
# Using the Advancement Degree of Difficulty ($AD^2$) as an input to Risk Management

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**Multi-dimensional Assessment of Technology Maturity**
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# Using AD² as an Input to Risk Management

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Advancement Degree of Difficulty (AD2) is a method of systematically dealing with aspects beyond TRL.

It is a "predictive" description of what is required to move a system, subsystem or component from one TRL to another.

It provides information in the form of:

- Liklihood of occurrence of an adverse event. } **Risk**
- Cost to ensure that such an event does not occur. } **Impact**
- The time required to implement the necessary action. } **Impact**


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- AD² consists of a set of questions in 5 specific areas:
  - Design and Analysis
  - Manufacturing
  - Software Development
  - Test
  - Operations
- The questions are asked about each element in the product WBS structure from the top level system down to the individual component.
- The questions are not directed toward the element itself, rather toward the issue of:
  - Do you have the resources – people, skills, tools, facilities, etc. to design, manufacture, test and operate it?


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The levels of risk associated with AD$^2$ are described in terms of the experience base of the developers.

**i.e., have they done this before?**


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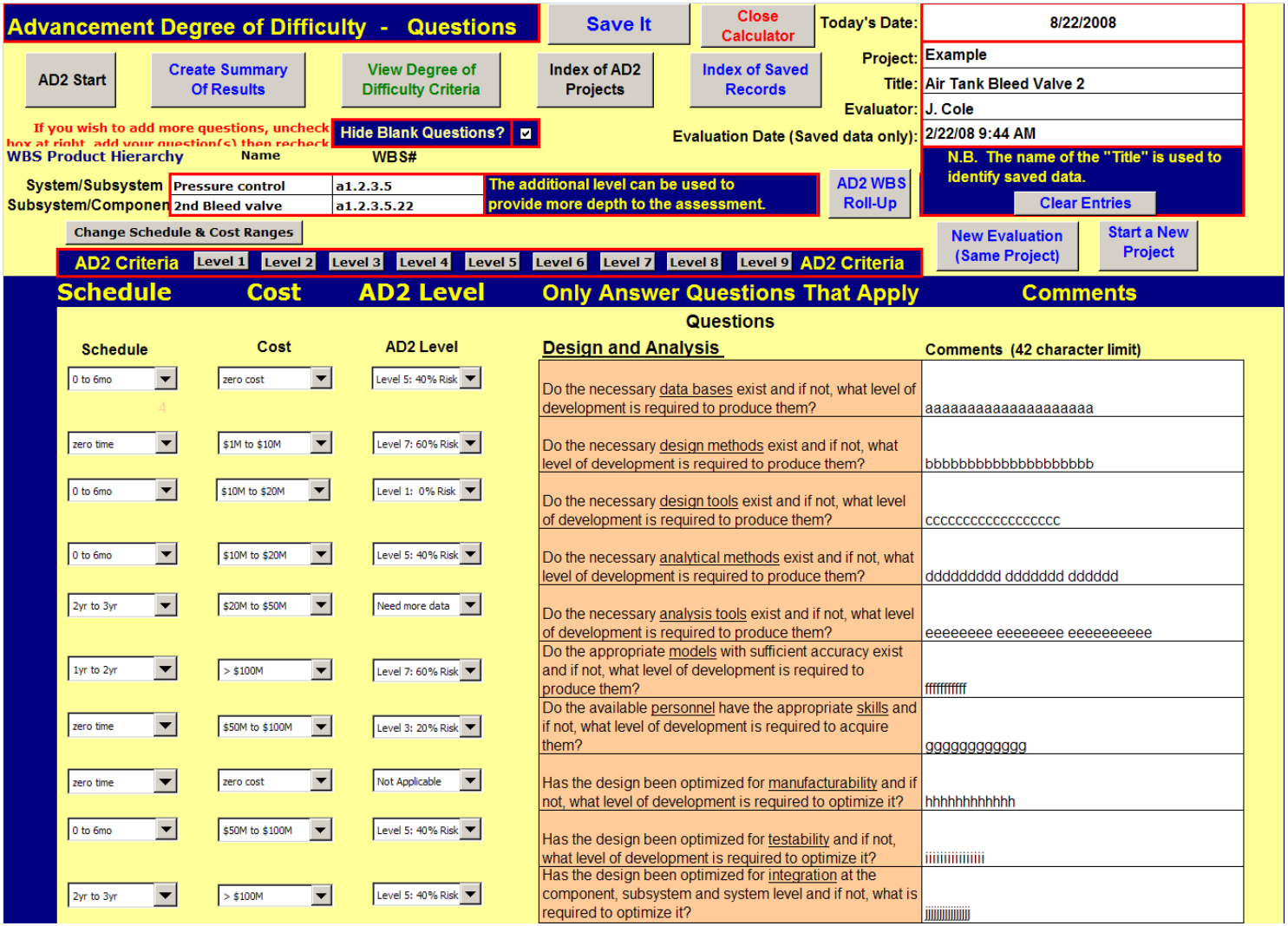
| AD² LEVEL | | RISK |
|---|---|---|
| 9 | Requires new development outside of any existing experience base. No viable approaches exist that can be pursued with any degree of confidence. Basic research in key areas needed before feasible approaches can be defined. | 90% |
| 8 | Requires new development where similarity to existing experience base can be defined only in the broadest sense. Multiple development routes must be pursued. | 80% |
| 7 | Requires new development but similarity to existing experience is sufficient to warrant comparison in only a subset of critical areas. Multiple development routes must be pursued. | 70% |
| 6 | Requires new development but similarity to existing experience is sufficient to warrant comparison on only a subset of critical areas. Dual development approaches should be pursued in order to achieve a moderate degree of confidence for success. (desired performance can be achieved in subsequent block upgrades with high degree of confidence. | 50% |
| 5 | Requires new development but similarity to existing experience is sufficient to warrant comparison in all critical areas. Dual development approaches should be pursued to provide a high degree of confidence for success. | 40% |
| 4 | Requires new development but similarity to existing experience is sufficient to warrant comparison across the board. A single development approach can be taken with a high degree of confidence for success. | 30% |
| 3 | Requires new development well within the experience base. A single development approach is adequate. | 20% |
| 2 | Exists but requires major modifications. A single development approach is adequate. | 10% |
| 1 | Exists with no or only minor modifications being required. A single development approach is adequate. | 0% |

# Using AD² as an Input to Risk Management



**Advancement Degree of Difficulty - Questions**

Save It | Close Calculator | Today's Date: 8/22/2008

AD2 Start | Create Summary Of Results | View Degree of Difficulty Criteria | Index of AD2 Projects | Index of Saved Records

Project: Example
Title: Air Tank Bleed Valve 2
Evaluator: J. Cole
Evaluation Date (Saved data only): 2/22/08 9:44 AM

If you wish to add more questions, uncheck box at right, add your question(s) then recheck | Hide Blank Questions? ☑

N.B. The name of the "Title" is used to identify saved data.

Clear Entries

| WBS Product Hierarchy | Name | WBS# |
|---|---|---|
| System/Subsystem | Pressure control | a1.2.3.5 |
| Subsystem/Componen | 2nd Bleed valve | a1.2.3.5.22 |

The additional level can be used to provide more depth to the assessment.

AD2 WBS Roll-Up

Change Schedule & Cost Ranges

New Evaluation (Same Project) | Start a New Project

AD2 Criteria | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 | Level 6 | Level 7 | Level 8 | Level 9 | AD2 Criteria

| Schedule | Cost | AD2 Level | Only Answer Questions That Apply — Questions | Comments (42 character limit) |
|---|---|---|---|---|
| 0 to 6mo | zero cost | Level 5: 40% Risk | Do the necessary data bases exist and if not, what level of development is required to produce them? | aaaaaaaaaaaaaaaaaaa |
| zero time | $1M to $10M | Level 7: 60% Risk | Do the necessary design methods exist and if not, what level of development is required to produce them? | bbbbbbbbbbbbbbbbbbb |
| 0 to 6mo | $10M to $20M | Level 1: 0% Risk | Do the necessary design tools exist and if not, what level of development is required to produce them? | ccccccccccccccccc |
| 0 to 6mo | $10M to $20M | Level 5: 40% Risk | Do the necessary analytical methods exist and if not, what level of development is required to produce them? | ddddddddd ddddddd dddddd |
| 2yr to 3yr | $20M to $50M | Need more data | Do the necessary analysis tools exist and if not, what level of development is required to produce them? | eeeeeeee eeeeeeee eeeeeeeeee |
| 1yr to 2yr | > $100M | Level 7: 60% Risk | Do the appropriate models with sufficient accuracy exist and if not, what level of development is required to produce them? | fffffffffff |
| zero time | $50M to $100M | Level 3: 20% Risk | Do the available personnel have the appropriate skills and if not, what level of development is required to acquire them? | ggggggggggg |
| zero time | zero cost | Not Applicable | Has the design been optimized for manufacturability and if not, what level of development is required to optimize it? | hhhhhhhhhhh |
| 0 to 6mo | $50M to $100M | Level 5: 40% Risk | Has the design been optimized for testability and if not, what level of development is required to optimize it? | iiiiiiiiiiiiii |
| 2yr to 3yr | > $100M | Level 5: 40% Risk | Has the design been optimized for integration at the component, subsystem and system level and if not, what is required to optimize it? | jjjjjjjjjjjjj |

# Using AD² as an Input to Risk Management

Return To AD2 Start

## AD2 Roll-up of Subsystem Drivers

Re-Calculate WBS Roll-up

8/22/08 4:28 PM

AD2 Current Evaluation | Index of Saved Records | Index of AD2 Projects

Sensitivity: Level 7: 60% Risk

Project: Example

| Record | WBS Sub Sys | Comp | Name | Problem Areas | Schedule | Cost | Tech Dev Needed |
|---|---|---|---|---|---|---|---|
| 5 | | 1.1.0 | | | | | |
| 5 | | 1.1.0 | Inducer | | | | |
| 3 | | 1.2.0 | Impeller | | | | |
| 4 | 1.3.0 | 1.3.1 | Pump Housing | | | | |
| 4 | | 1.3.1 | Volute | | | | |
| 6 | | 1.3.2 | Diffuser | | | | |
| 7 | | 1.4.0 | Turbine Blades | | | | |
| 8 | | 1.5.0 | Turbine Nozzles | | | | |
| 11 | 1.6.0 | 1.6.1 | Turbine Housing | | | | |
| 11 | | 1.6.1 | Manifolds | | | | |
| 9 | | 1.6.2 | Guide Vanes | | | | |
| 10 | | 1.7.0 | Dynamic Seals | | | | |
| 12 | | 1.8.0 | Bearings/Rotor | | | | |
| 13 | | 1.10.0 | Axial Thrust Balance | | | | |
| 14 | | 1.10.2 | Axial Thrust Balance2 | | | | |
| 2 | a1.2.3.5 | a1.2.3.5.21 | Pressure control | | | | |
| 2 | | a1.2.3.5.21 | Bleed valve | | | | |
| | | | | D&A - Necessary data bases | zero time | zero cost | Level 7: 60% Risk |
| | | | | D&A - Appropriate skills | zero time | $50M to $100M | Level 7: 60% Risk |
| | | | | D&A - | zero time | zero cost | Level 8: 80% Risk |
| | | | | Mfg - Necessary metrology | zero time | $20M to $50M | Level 7: 60% Risk |
| | | | | Mfg - Appropriate skills | 0 to 6mo | > $100M | Level 7: 60% Risk |
| | | | | Mfg - | 6mo to 1yr | $1M to $10M | Level 7: 60% Risk |
| | | | | SW Dev - | 1yr to 2yr | $20M to $50M | Level 7: 60% Risk |
| | | | | T&V - Test facilities | 6mo to 1yr | $1M to $10M | Level 7: 60% Risk |
| 1 | | a1.2.3.5.22 | 2nd Bleed valve | | | | |
| | | | | D&A - Necessary design methods | zero time | $1M to $10M | Level 7: 60% Risk |
| | | | | D&A - Necessary analysis tools | 2yr to 3yr | $20M to $50M | Need more data |
| | | | | D&A - Models with sufficient accuracy | 1yr to 2yr | > $100M | Level 7: 60% Risk |
| | | | | D&A - Optimized for manufacturability | zero time | zero cost | Not Applicable |
| | | | | D&A - | zero time | zero cost | Level 7: 60% Risk |
| | | | | D&A - | 2yr to 3yr | $50M to $100M | Level 9: 100% Risk |
| | | | | Mfg - Necessary materials | 1yr to 2yr | $10M to $20M | Need more data |
| | | | | Mfg - Necessary mfg. tooling | 6mo to 1yr | $20M to $50M | Not Applicable |
| | | | | Mfg - Necessary metrology | zero time | $20M to $50M | Level 7: 60% Risk |
| | | | | Mfg - Necessary mfg. software | 0 to 6mo | 0 to $1M | Level 7: 60% Risk |
| | | | | Mfg - Brassboards | zero time | zero cost | Not Applicable |
| | | | | Mfg - Qualification models | 0 to 6mo | $50M to $100M | Not Applicable |
| | | | | Mfg - | 2yr to 3yr | 0 to $1M | Need more data |
| | | | | Mfg - | 6mo to 1yr | $1M to $10M | Level 9: 100% Risk |
| | | | | SW Dev - | 0 to 6mo | $20M to $50M | Level 8: 80% Risk |
| | | | | SW Dev - | zero time | $20M to $50M | Level 9: 100% Risk |
| | | | | SW Dev - | zero time | $50M to $100M | Not Applicable |
| | | | | SW Dev - | 1yr to 2yr | $20M to $50M | Need more data |


# Using AD² as an Input to Risk Management

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## Relating AD² to Project Uncertainty: from Variation to Chaos*

**Variation:**

**Cost, time and performance levels vary randomly, but in a predictable range.**

**Foreseen Certainty:**

**A few known factors will influence the project but in predictable ways.**

**Unforeseen Uncertainty:**

**One or more major influence factors cannot be predicted.**

**Chaos:**

**Unforeseen events completely dominate the project's target, planning and approach.**

*De Meyer, et al

# Using AD² as an Input to Risk Management

## TRL AD2 Project Status Definition

| Project Type | Current TRL | AD2 Risk Level | Project Status |
|---|---|---|---|
| Basic Research | TRL 1 or 2 | AD2L 1, 2,3,4 | Acceptable |
| Applied Research | TRL 3 or 4 | AD2L 5 | |
| Advanced Research | TRL 5 | AD2L 6,7,8,9 | |
| Advanced Tech Demonstrator | TRL 6, 7 | | |
| Acquisition Program | TRL 8, or 9 | | |

Reset All

| TRL | Adv. Tech Demo | Level | AD2 | | Risk |
|---|---|---|---|---|---|
| Actual system flight proven through successful mission operations | Too well known for Advanced Tech Demonstrator | 9 | Chaos | Requires new development outside of any existing experience base. No viable approaches exist that can be pursued with any degree of confidence. Basic research in key areas needed before feasible approaches can be defined. | 90+% |
| Actual system completed and flight qualified through test and demonstration | Too well known for Advanced Tech Demonstrator | 8 | Unknown Unknowns | Requires new development where similarity to existing experience base can be defined only in the broadest sense. Multiple development routes must be pursued. | 80% |
| System/subsystem model or prototype demonstration in a relevant environment | Desirable | 7 | | Requires new development but similarity to existing experience is sufficient to warrant comparison in only a subset of critical areas. Multiple development routes must be pursued. | 70% |
| System/subsystem model or prototype demonstration in a relevant environment | Desirable | 6 | | Requires new development but similarity to existing experience is sufficient to warrant comparison on only a subset of critical areas. Dual development approaches should be pursued in order to achieve a moderate degree of confidence for success. (desired performance can be achieved in subsequent block upgrades with high degree of confidence. | 50% |
| Component or breadboard validation in a relevant environment | Acceptable | 5 | Known Unknowns | Requires new development but similarity to existing experience is sufficient to warrant comparison in all critical areas. Dual development approaches should be pursued to provide a high degree of confidence for success. | 40% |
| Component or breadboard validation in laboratory | Unacceptable -- Too Risky | 4 | Well Understood | Requires new development but similarity to existing experience is sufficient to warrant comparison across the board. A single development approach can be taken with a high degree of confidence for success. | 30% |
| Analytical and/ or experimental critical function or characteristic proof-of-concept | Unacceptable -- Too Risky | 3 | | Requires new development well within the experience base. A single development approach is adequate. | 20% |
| Technology concept or application formulated | Unacceptable -- Too Risky | 2 | | Exists but requires major modifications. A single development approach is adequate. | 10% |
| Basic principles observed and reported | Unacceptable -- Too Risky | 1 | | Exists with no or only minor modifications being required. A single development approach is adequate. | 0% |

TRL Increasing Maturity

AD2 Increasing Risk


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## Relating AD² to a 5X5 Risk Matrix

### DOD Likelihood Descriptions

Likelihood

| Level | Likelihood | Probability of Occurrence |
|---|---|---|
| 1 | Not Likely | ~10% |
| 2 | Low Likelihood | ~30% |
| 3 | Likely | ~50% |
| 4 | Highly Likely | ~70% |
| 5 | Near Certainty | ~90% |


# Using AD² as an Input to Risk Management

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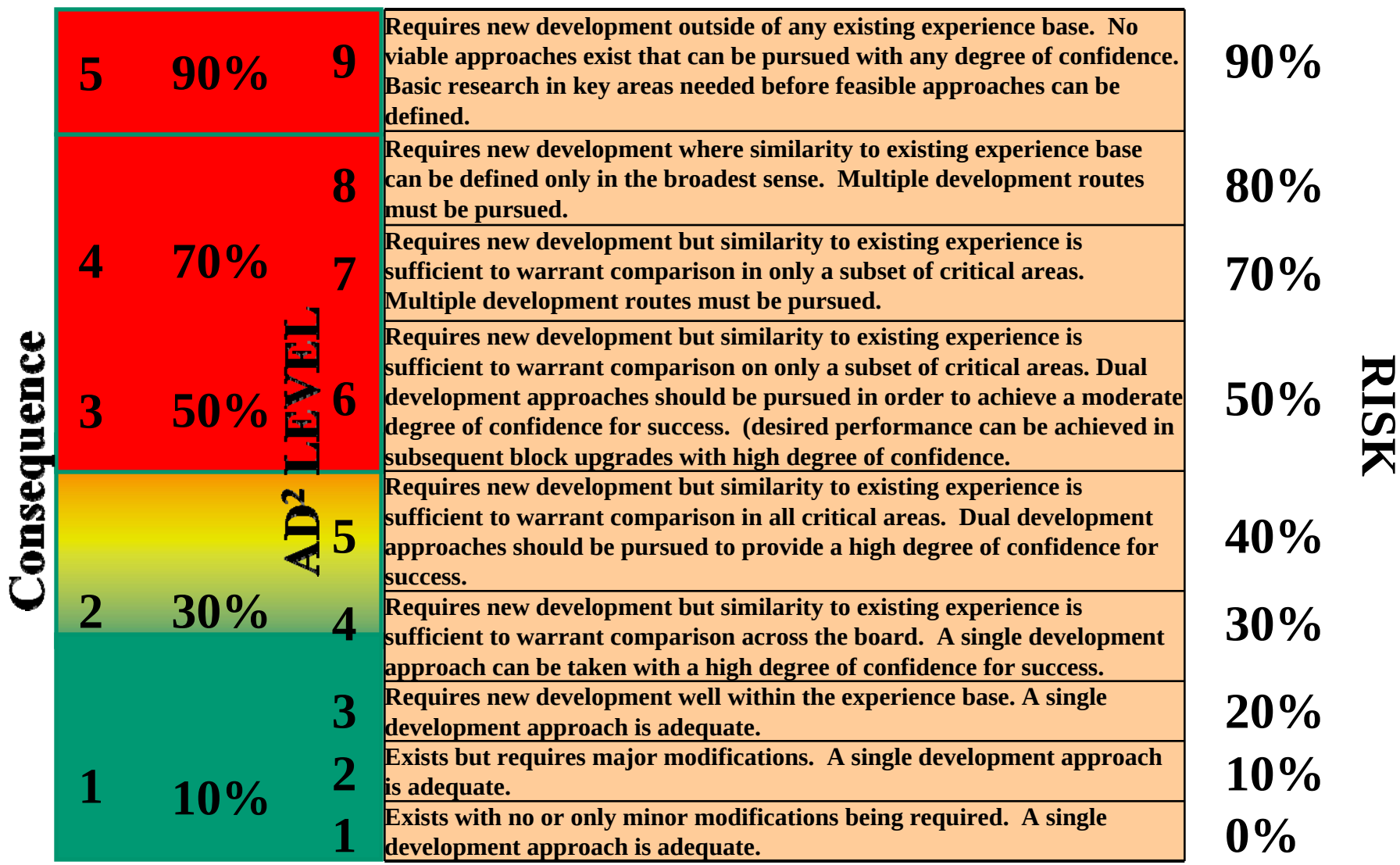
## DOD Consequence Descriptions

Consequence

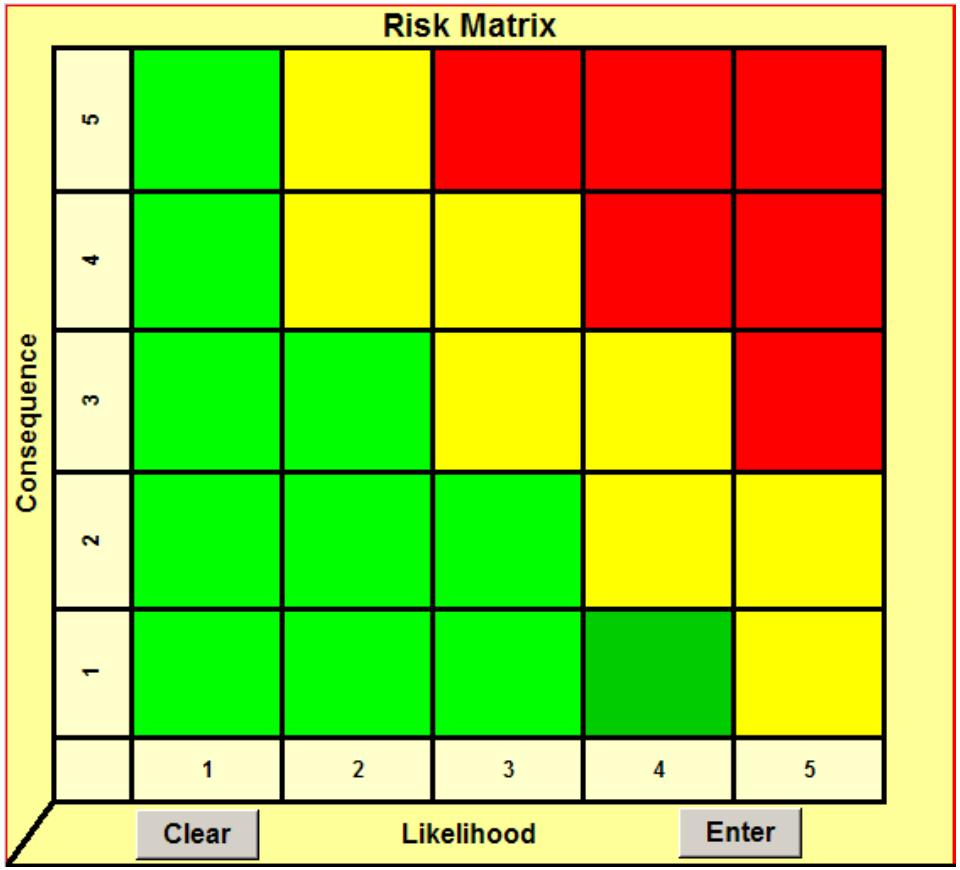
| Level | Technical | Schedule | Schedule |
|---|---|---|---|
| 1 | Minimal or no consequence to technical performance | Minimal or no impact | Minimal or no impact |
| 2 | Minor reduction in technical performance or supportability, can be tolerated with little or no impact on the program | Able to meet key dates.<br><br>**Slip <*month(s)** | Budget increase or unit production cost increases.<br><br>**<**(1% of Budget)** |
| 3 | Moderate reduction in technical performance or supportability with limited impact on program objectives | Minor schedule slip. Able to meet key milestones with no schedule float<br>**Slip <*month(s)**<br>**Sub-system slip<*month(s) plus available float** | Budget increase or unit production cost increases.<br><br>**<**(5% of Budget)** |
| 4 | Significant degradation in technical performance or major shortfall in supportability; may jeopardize program success | Program critical path affected<br><br>**Slip <*month(s)** | Budget increase or unit production cost increases.<br><br>**<**(10% of Budget)** |
| 5 | Severe degradation in technical performance. Cannot meet KPP or key technical/supportability threshold; will jeopardize program success | Cannot meet key program milestones<br><br>**Slip <*month(s)** | Budget increase or unit production cost increases.<br><br>**>**(10% of Budget)** |

# Using AD² as an Input to Risk Management



# Using AD² as an Input to Risk Management

## 5X5 Risk Matrix




# Using AD² as an Input to Risk Management

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## Summary

- **The AD2 assessment provides the basis for the development of the Technology Development Plan and for improved accuracy of the development of program/project cost, schedule and risk.**

# Using AD² as an Input to Risk Management

**Website:** www.jbconsultinginternational.com

**Bibliography:**


- De Meyer, Arnould, Loch, Christoph H., and Pich Michael T., "Managing Project Uncertainty: From Variation to Chaos," MIT Sloan Management Review, pp. 60-67, Winter 2002.
- Risk Management Guide for DOD Acquistion 6th Edition Version 1.0 August 2006.